KERR WOOD LEIDAL
consulting engineers

58th INTERNATIONAL CONFERENCE ON WATER MANAGEMENT MODELING

Development and Calibration Challenges for a Large Confined Drainage System Model

Vancouver International Airport

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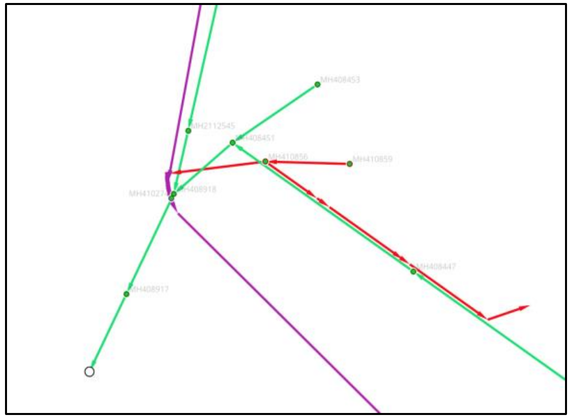
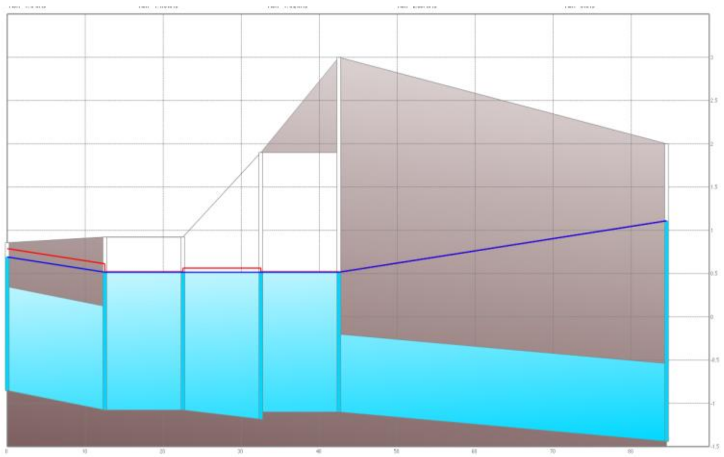
Junior Engineer for Kerr Wood Leidal, BC, Canada

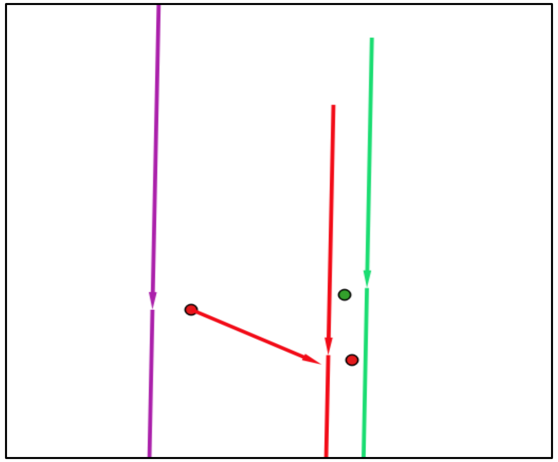
- Over 6 years of modelling experience with HEC, MIKE and SWMM platforms.
- Worked for projects in Canada, USA, Norway, Sweden, Denmark, India, Philippines and Nigeria
- Master of Engineering in Hydrology and Water Resources (2018), Anna University, Chennai
- Bachelor of Civil Engineering (2013), Anna University, Chennai

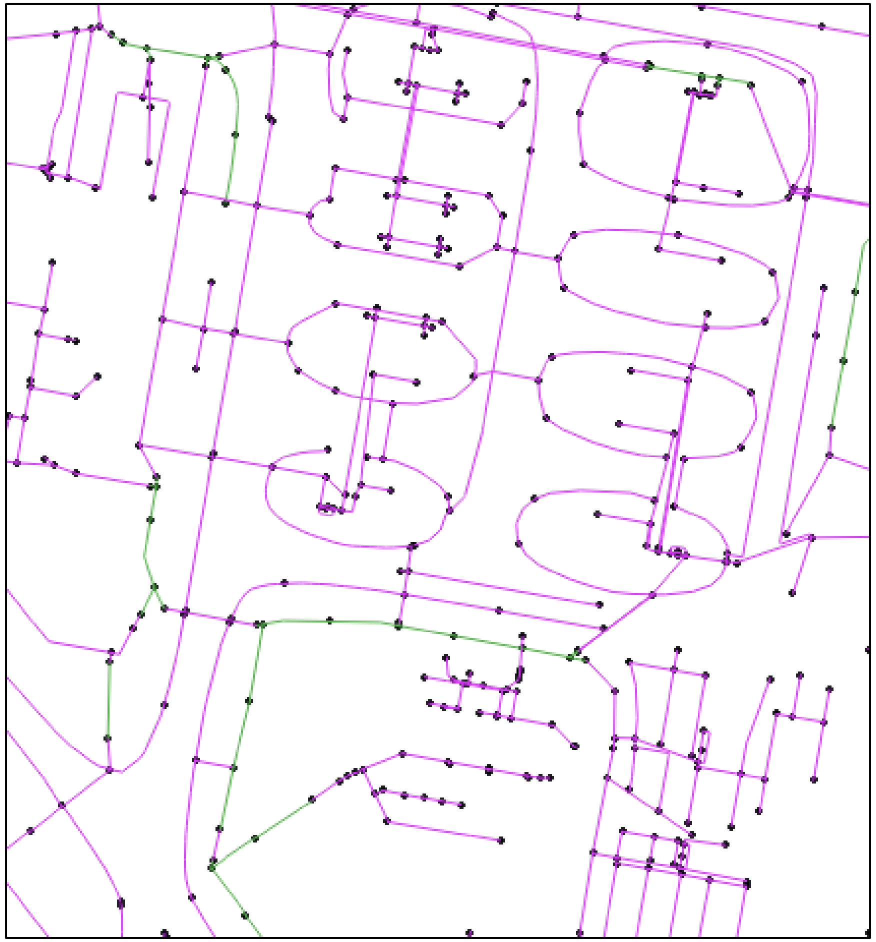
MODELLING CHALLENGES

- Data gaps
- Data quality
- Data size
- Level of accuracy
- Complexity of the site
- Project timeline
- Software limitation







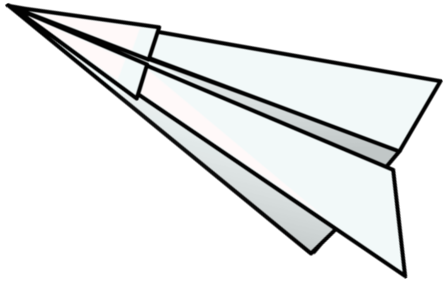


OVERVIEW

Kerr Wood Leidal Associates Ltd. (KWL) was awarded a modelling project to assist Vancouver Airport Authority (VAA) with,

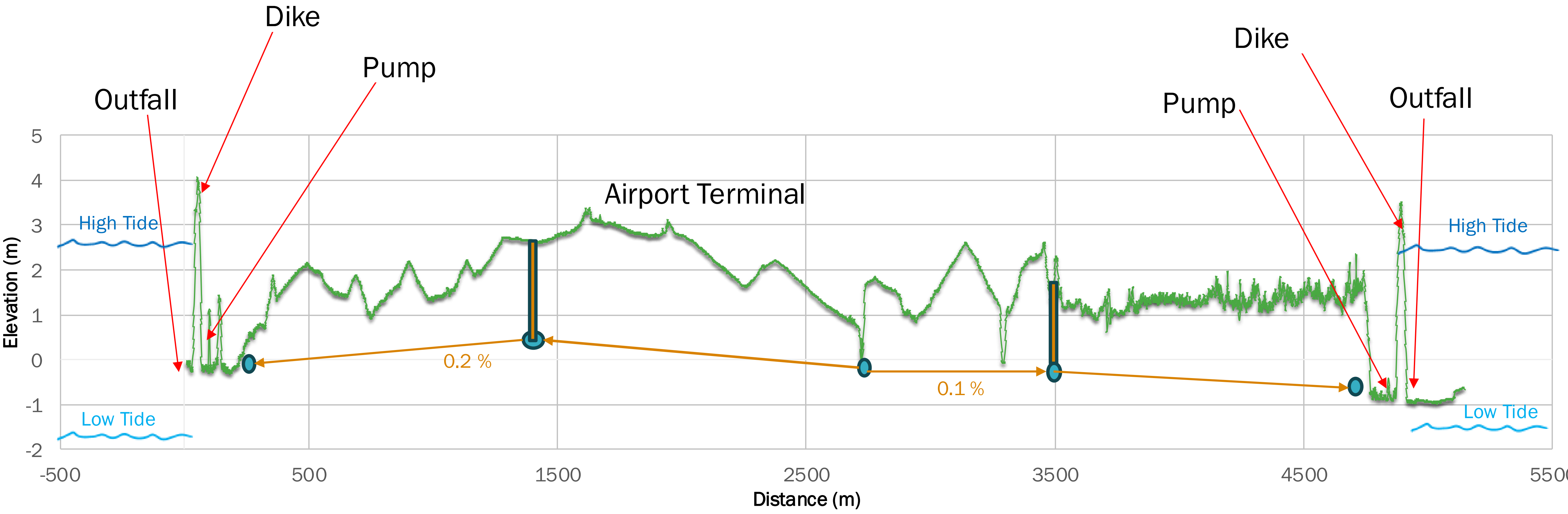
- understanding how the drainage system performs under existing and anticipated future conditions
- to support decision-making related to management, maintenance, operation, and upgrades.

SITE FEATURES



- YVR is located on Sea Island, at the mouth of the Fraser River.
- Most of the island is at or near sea level.
- The island is protected by a full perimeter dike.
- Extensive confined drainage system conveys the storm runoff towards outfalls and pumped out.

SITE CROSS SECTION EXAMPLE



Source: https://www.richmond-news.com/local-news/video-flooding-on-gilbert-and-blundell-roads-in-richmond-4758482

Source: https://globalnews.ca/news/6297812/vancouver-airport-flooding/

MODELLING APPROACH

Data collection
- Quality checks
- Identifying gaps

Data digitization
- Drawings

Surveying
- LiDAR
- Ground surveying

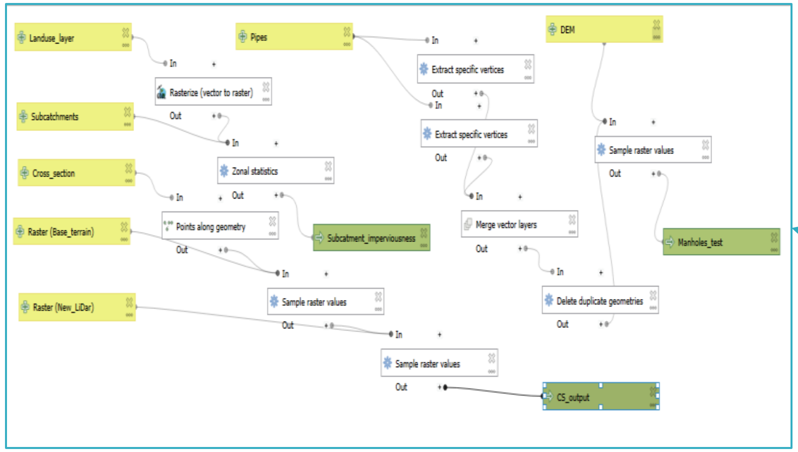
Filling data gaps
- GIS Tools
- Assumptions

Software selection
- SWMM, MIKE, InfoWorks ICM

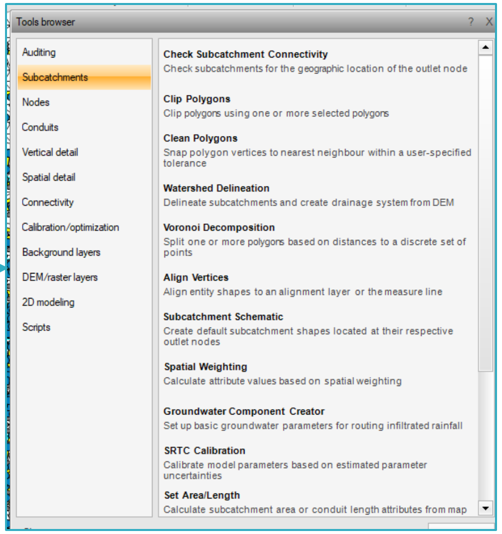
Model selection
- 1D model
- 2D model
- 1D dual model
- Integrated 1D-2D model

Challenges
- Network connectivity
- Pipe direction
- 2D Mesh resolution
- Model stability
- Pump operations

Calibration and validation
- Summer and winter event
- Initial calibration using Parallax tool
- Sensitivity analysis
- Additional model modification
- Final Calibration and validation



Data cleaning and analysis tools

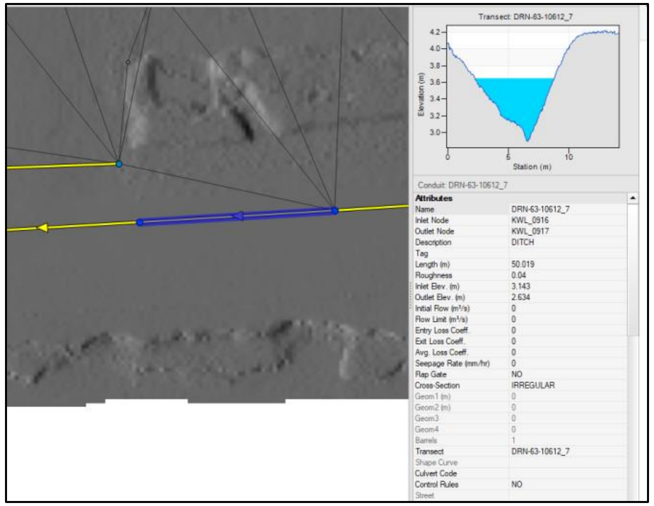


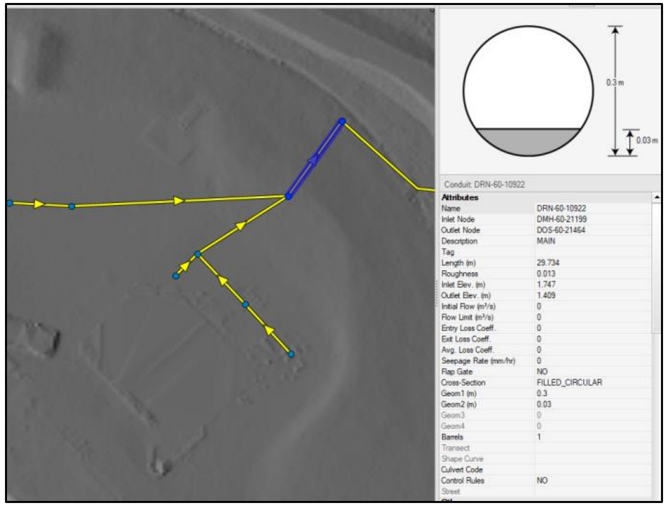
CADD
Arc Map
RAS mapper
R-Studio

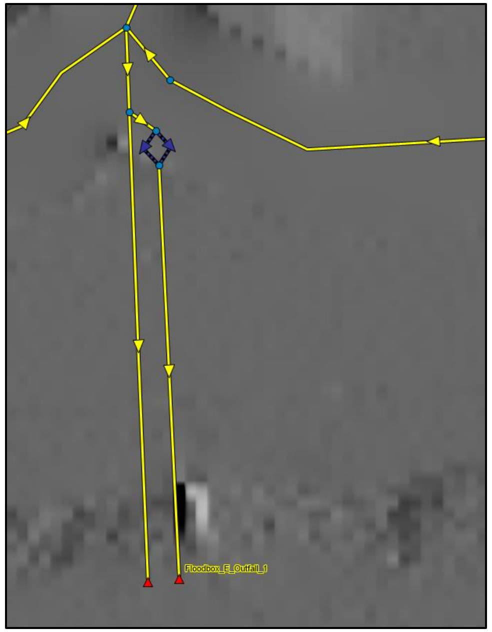
DATA COMPILATION AND REVIEW FOR MODELLING

1D conveyance model

- Combining Multiple Data Sources
- Data Source Tracking and Notations
- Ditch Network
- Piped Network
- Outfalls
- Pump Stations







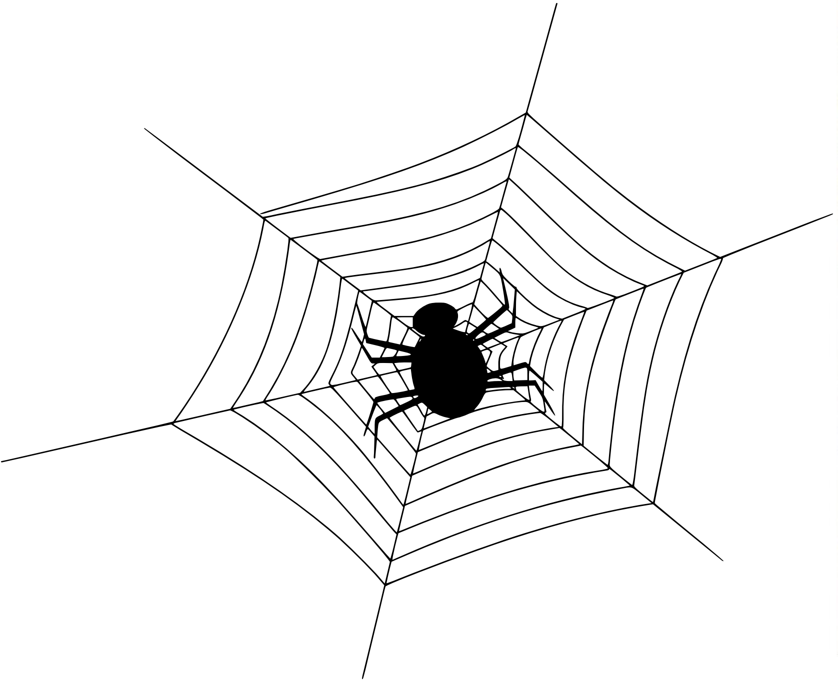
DATA COMPILATION AND REVIEW FOR MODELLING

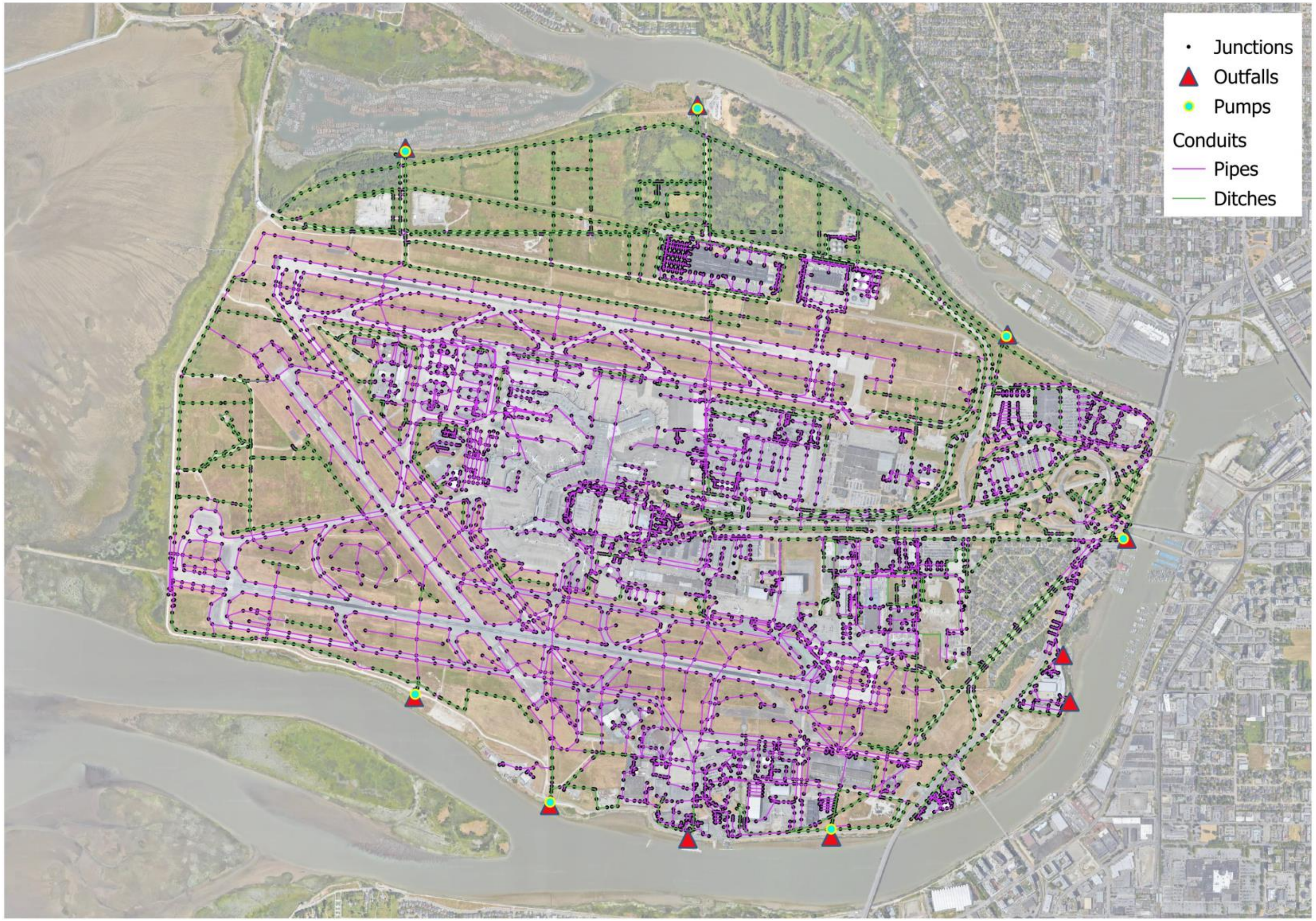
Junction: 7000 +

Conduits: 7000+

Outfall: 10

Pumps: 7



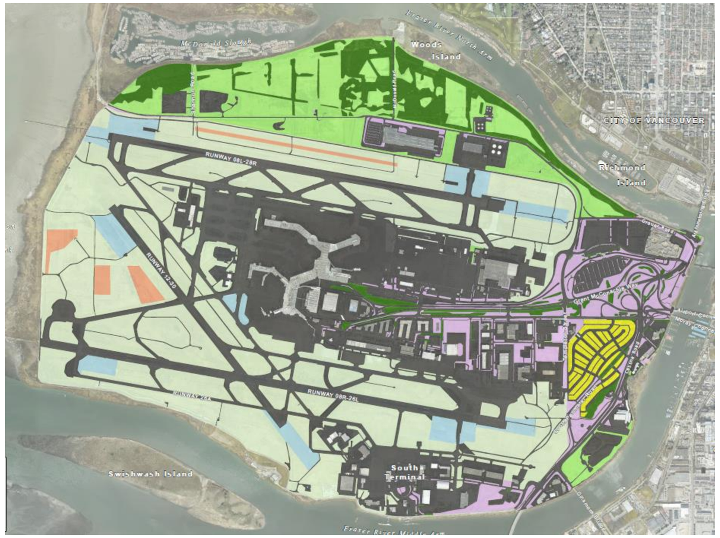


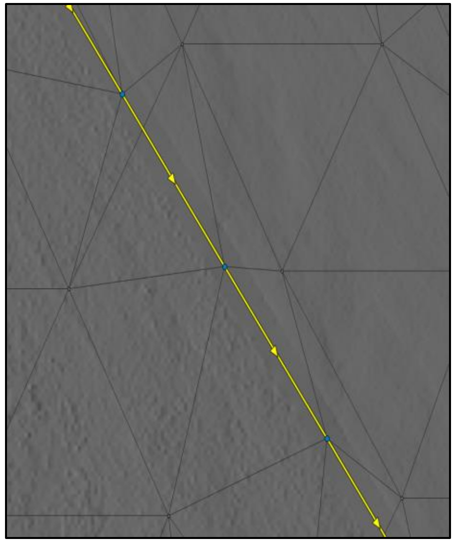
DATA COMPILATION AND REVIEW FOR MODELLING

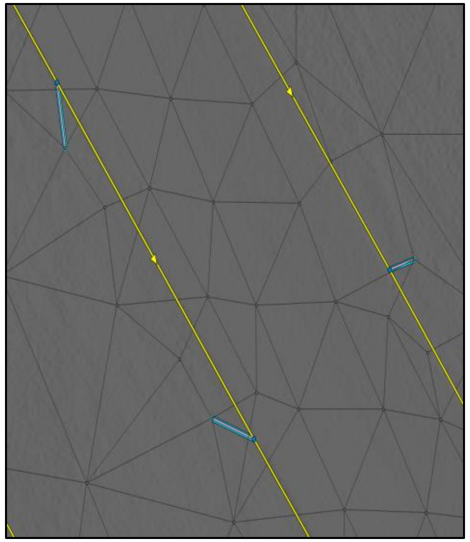
2D Surface model

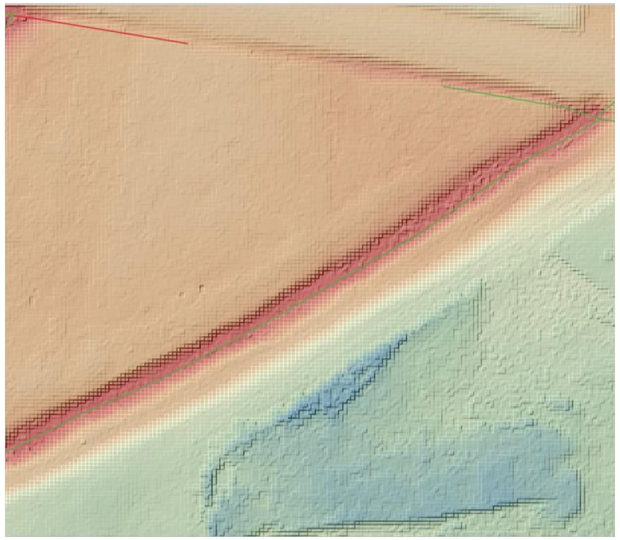
- Existing Conditions Land Cover Layer
- Removing Buildings from the 2D Surface
- Removing 1D Ditch Areas from 2D Surface
- Connecting the 2D Surface to 1D Model Elements
    - Direct Connections
    - Outlet Connections (2D to 1D)
    - Weir Connections (1D to 2D)

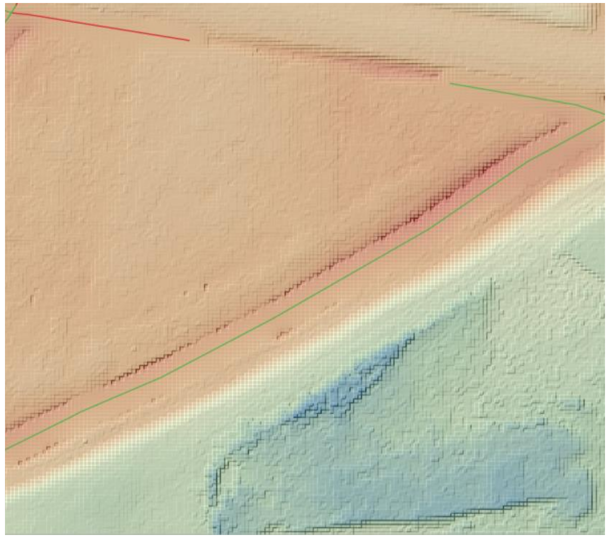
Mesh resolution: 10m to 100m

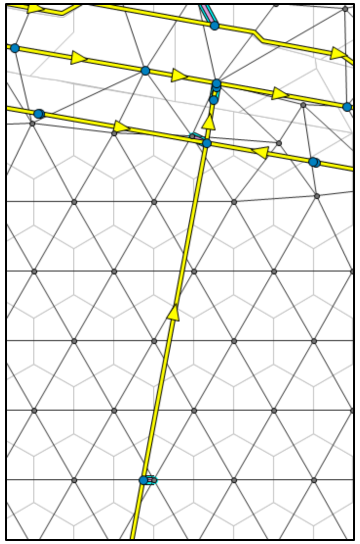












Data Compilation and Review for Modelling

Hydrological model

- Model Catchment Delineation
  - Roof Catchments (area greater than 100 sq.m)
  - 2D Cell Catchments
- Model Parameters
  - Infiltration
  - Evaporation
  - Groundwater

Catchment area: 1500 ha (approximately)

MODEL CALIBRATION

Overview

Locations

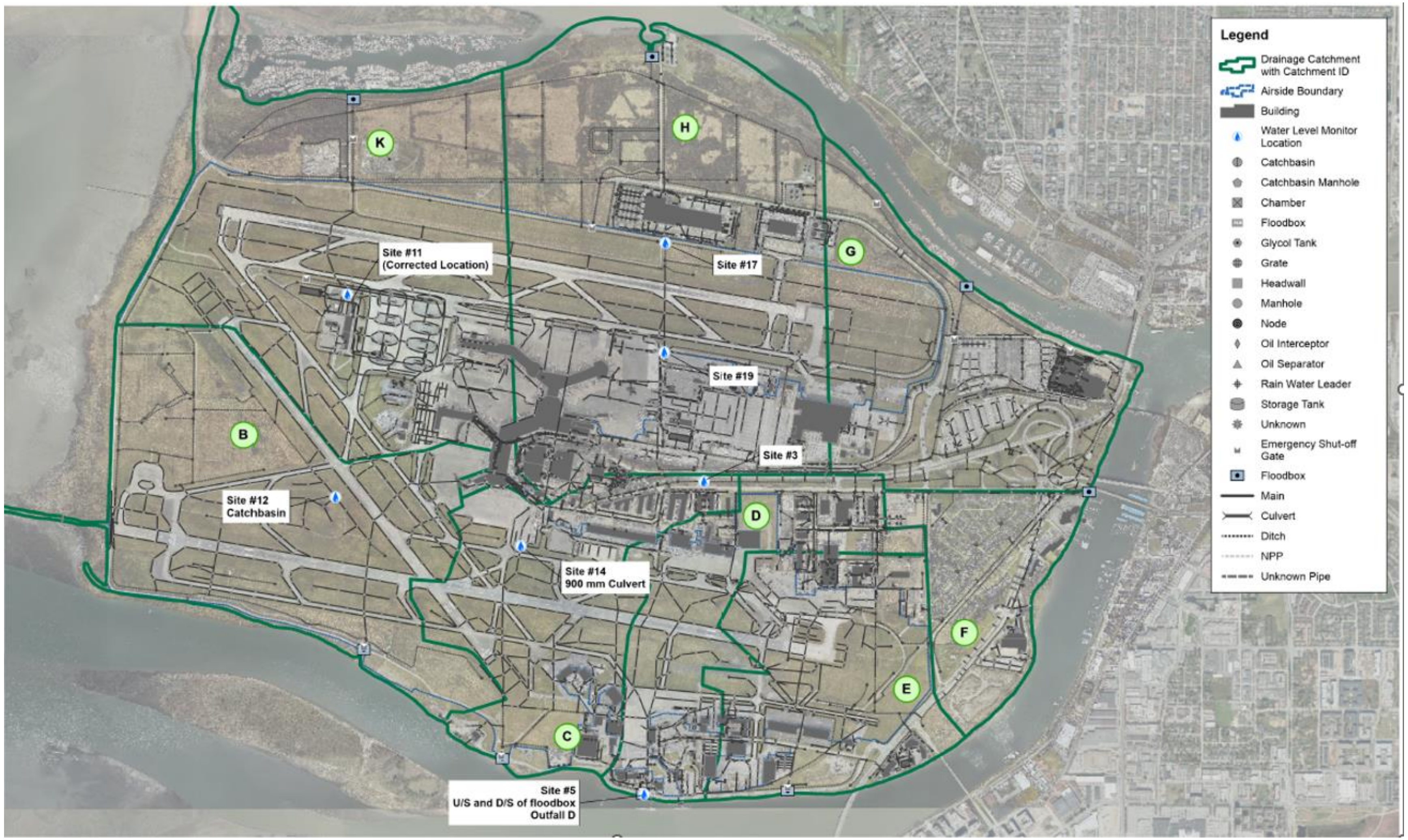
- 13 location

Events

- Winter
- Summer

Phase

- Initial calibration and Sensitivity analysis (Parallax and SRTC)
- Impact Evaluation
- Final calibration



CALIBRATION PHASE 1

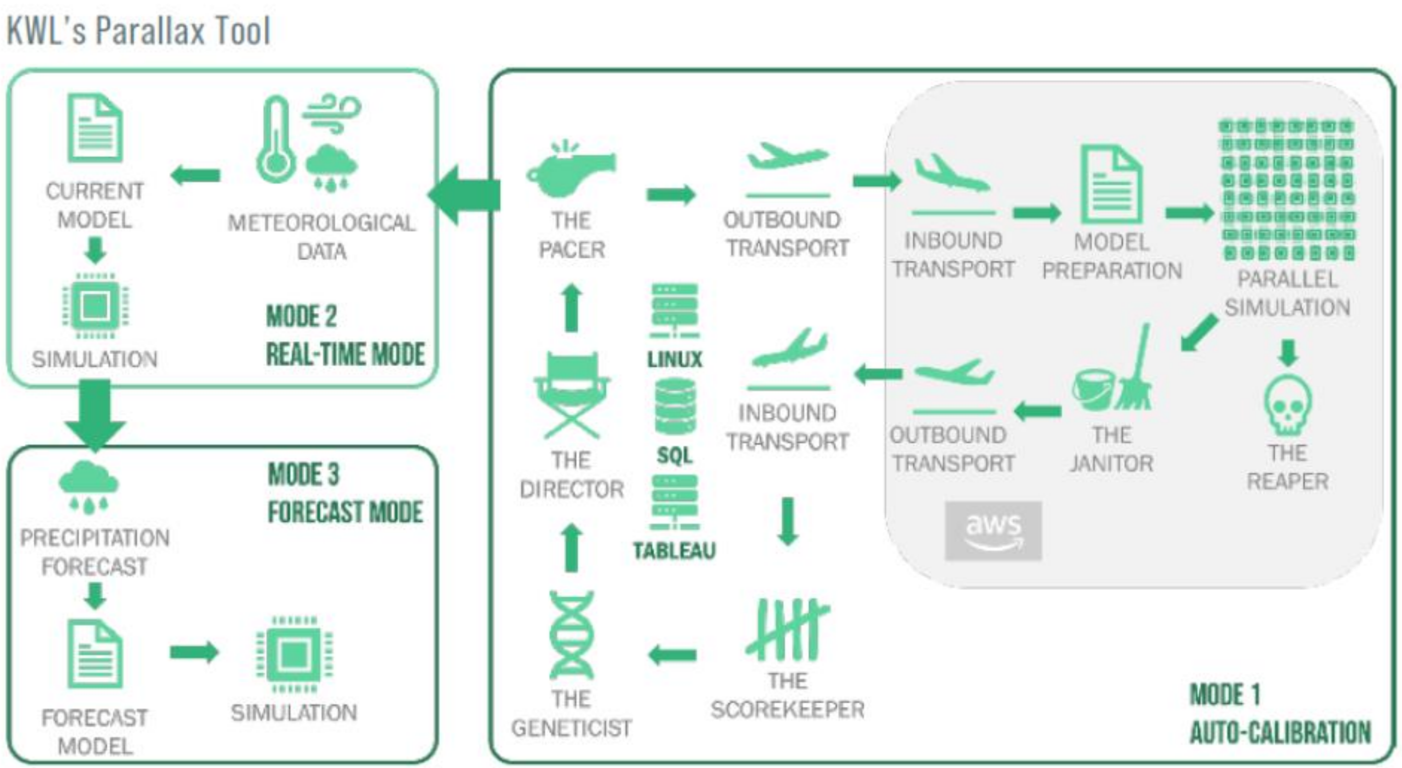
Phase 1: Parallax and Sensitivity Runs

Parallax

- KWL's internally developed model calibration tool
- Runs several simulations to determine the best set of parameters for the scenario

Sensitivity-based Radio Tuning Calibration (SRTC)

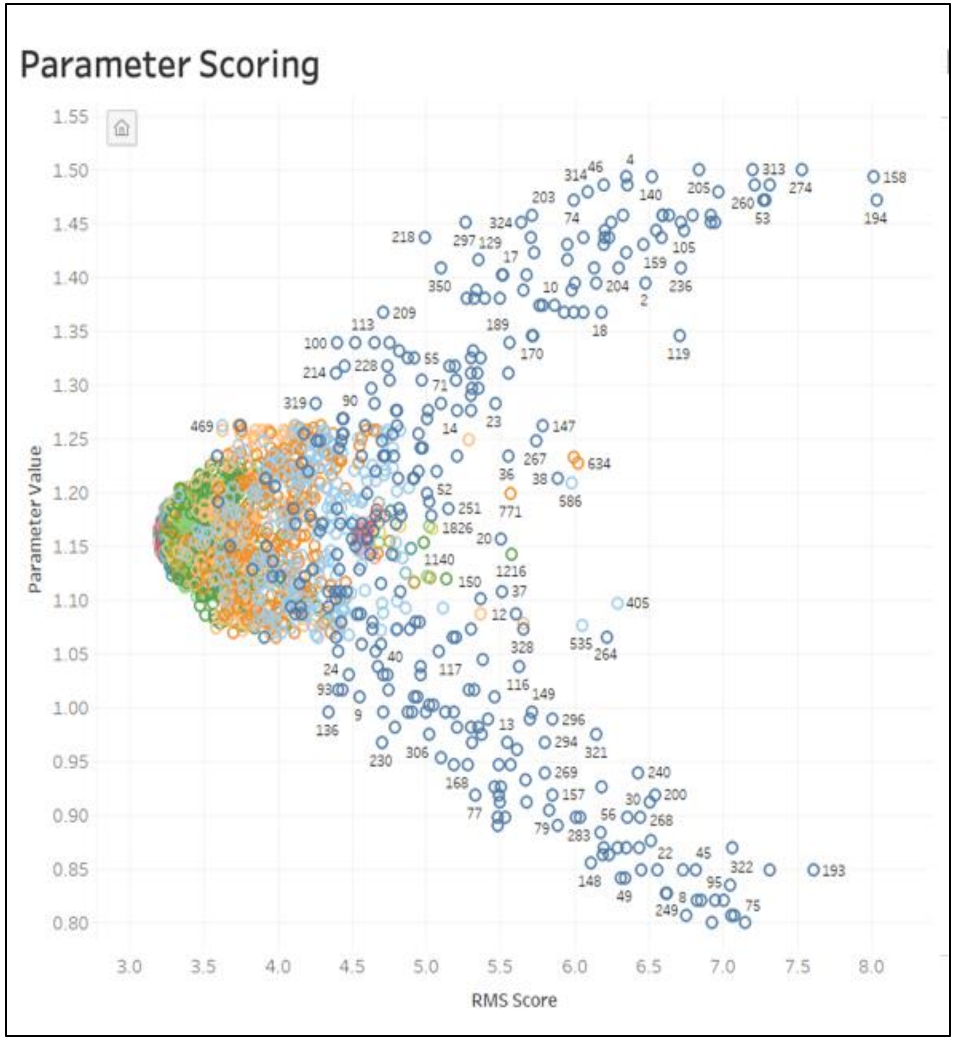
- Following Parallax, SRTC tool was used to determine model sensitivity to different parameters.



Calibration phase 1

Parallax feature

- Allows modellers to use parallel cloud processing.
- Uses python programming to create model input files that modify user specified parameters within reasonable ranges.
- Leverages hundreds (or even thousands) of processor cores in the cloud to test how certain parameters affect the calibration, “learning” from these results, selecting only the best of each “generation” for the next trials, and iterating the process.
- 100s to 1000s of model simulations are completed using Amazon Web Services
- Each model run is scored (RMS, Nash–Sutcliffe, etc) to determine the ”best” combination of parameters matches the observed data.
- Works on most open source hydrologic/hydraulic/water quality software (SWMM, SWATT, HEC, Raven etc.)



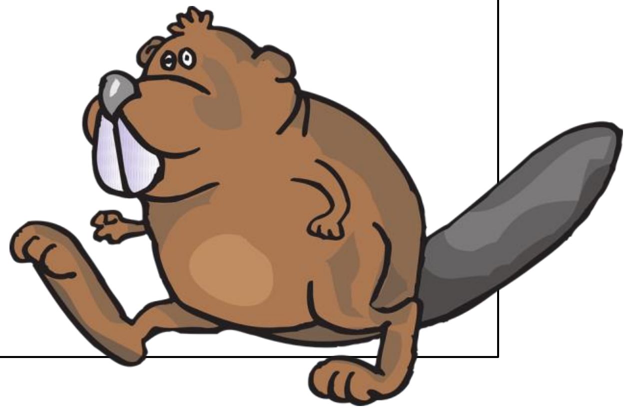
CALIBRATION PHASE 2-3

Phase 2: Impact Evaluation and additional model modification

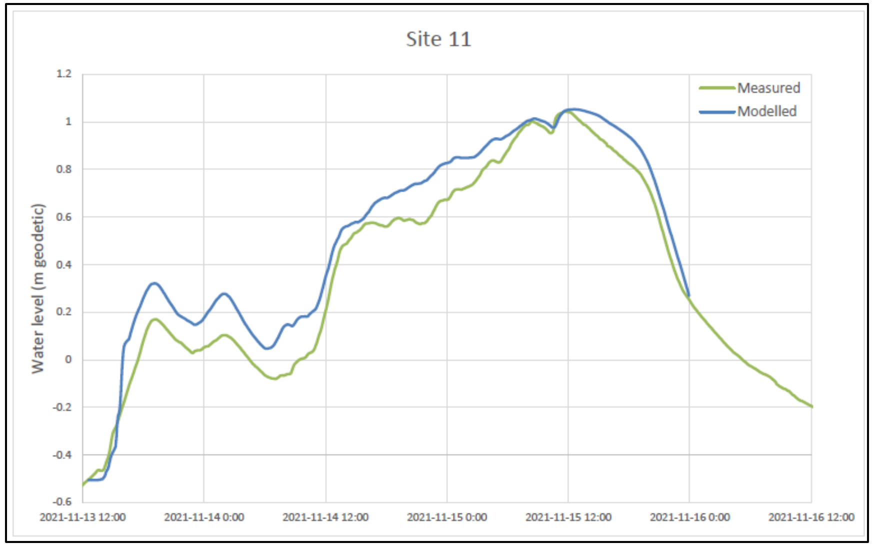
- Result discussion with client
- Flagging model flooded areas where flooding never occurred
- Updating model with recommended changes.
- Results comparison after changes

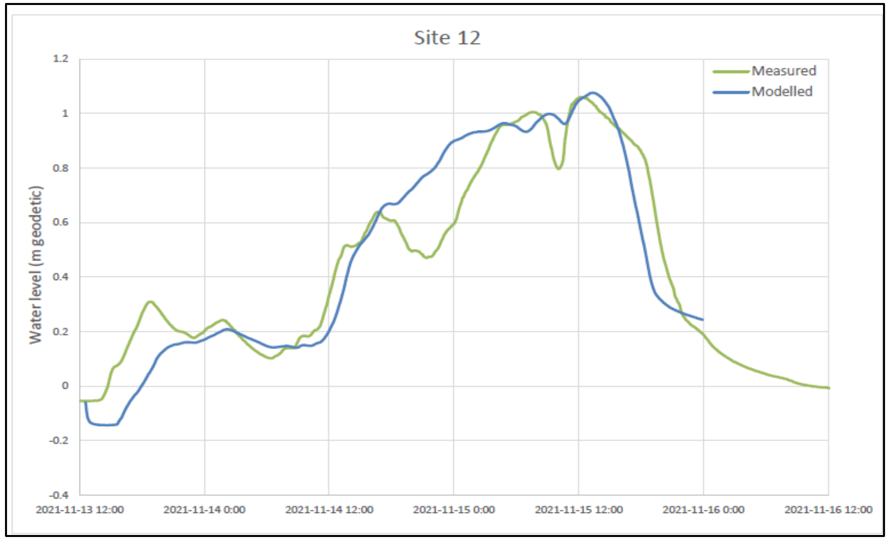
Phase 3: Final calibration

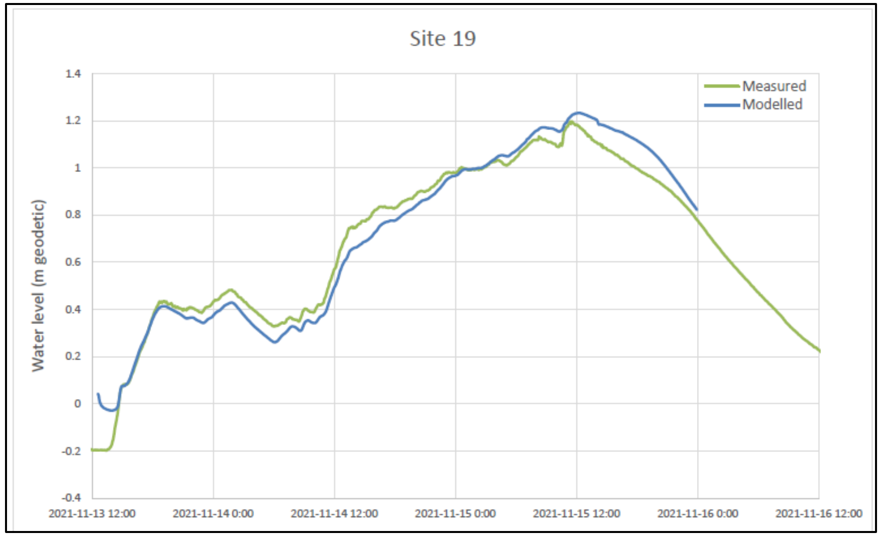
- Discussion with client regarding system maintenance issues
- Updating the model with blockages from sediments, beaver dams and flapgate obstructions

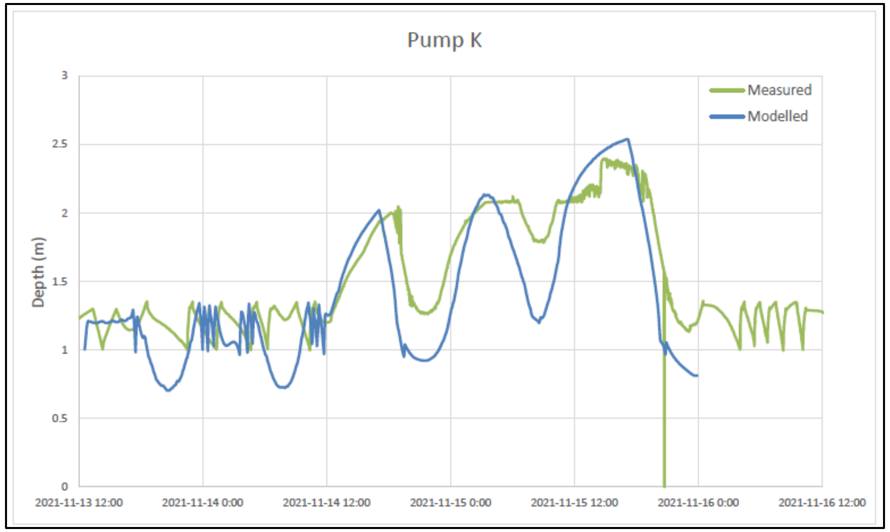


CALIBRATION GRAPHS









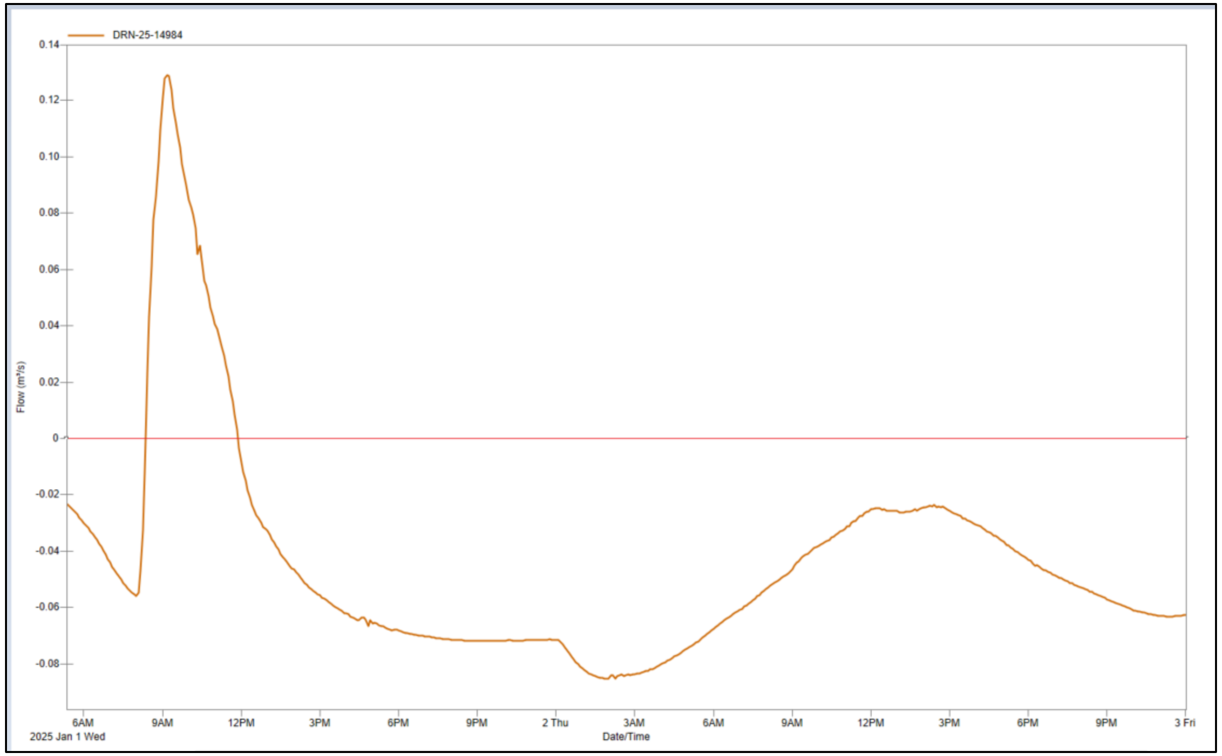
LIMITATION AND CHALLENGES

Model limitation

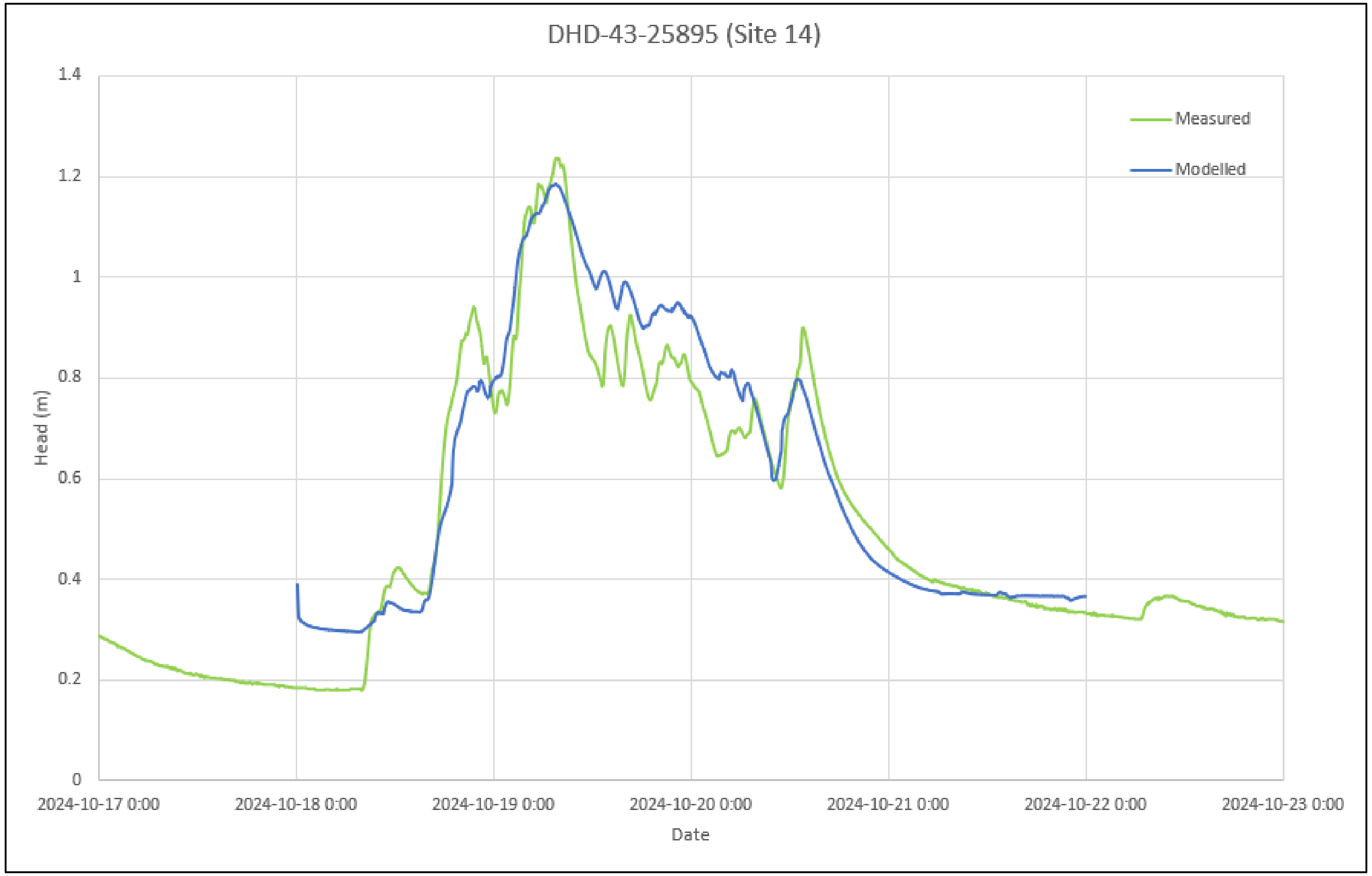
- No Flow data, only water level data
- Model assumes same sediment build up in the pipe throughout the network
- The complexity of groundwater in the island, and seepage through dike and other underground connection remains unidentified.

Model Challenges

- Data gaps and collection.
- Surveying airside area challenges
- Long runtime (less than one simulation hour per actual hour)
- Backwater flow and interconnectivity between different drainage path



VALIDATION



Model Validation

- The model was validated with the recent October 2024 rain event.

CONCLUSION

Data Handling Experience	Modelling Experience	Innovative techniques	Limitations
Compiling	1D/2D integrated model	Parallax	Data quality
Cleaning/ Formatting	Calibration techniques	GIS tools	Model limitation
Analysis	Result interpretation	Python tools	Computer capacity, time, budget

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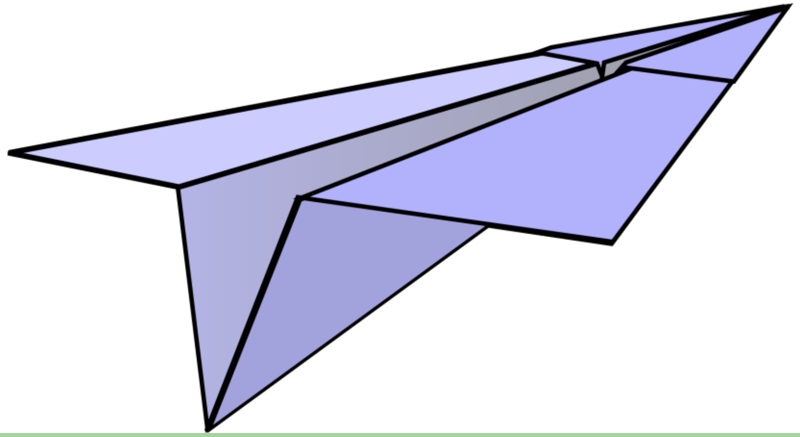

THANK YOU

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